Renewable and Sustainable Energy Reviews 31 (2014) 1–8

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Investment, security of supply and sustainability in the aftermath of three decades of power sector reform

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ARTICLE INFO

Article history:
Received 8 April 2013
Received in revised form
23 October 2013
Accepted 12 November 2013
Available online 5 December 2013

Keywords:
Econometric modeling
Institutions and the macroeconomy
Electric utilities
Market design

ABSTRACT

The last three decades have witnessed many electricity industry reform processes in more than half of the countries in the world. The reforms have aimed, *inter alia*, at encouraging private investments in electricity infrastructure, enhancing security of electricity supply and making power industry operate in line with the requirements of the sustainable development. Using an original panel dataset from 55 developed and developing countries covering the period from 1975 to 2010, this study aims at finding out to what extent these objectives have been materialized so far. Econometric models are used to identify the effects of electricity market liberalization on these variables. The research findings suggest that the progress toward the electricity market reform is associated with a decline in private investments in the electricity industries of developing countries, higher levels of self-sufficiency in electricity supply and lower CO_2 emissions from electricity generation.

Contents

1. Introduction

The initial push for the creation of power grids was private but it was not long before deeper government involvement was evidenced. This occurred with varying degrees across countries, especially after World War II [1]. However, whether private or not, electricity industry was regarded as a natural monopoly in almost all countries and structured as a vertically integrated utility. The rationale for this includes some judgments about the industry. First of all, it was believed that in the electricity sector one firm produces output less expensively than if there were multiple firms in the market as average costs declined as output increased. It was also argued that there exist markets (like electricity market) served by a small number of firms, which are nevertheless characterized by competitive equilibrium (and therefore desirable welfare outcomes) because of the existence of potential short-term entrants [2]. Besides, government ownership of the monopoly (or public regulation) was justified on the grounds that the state was the guardian of the public interest and therefore would be the least likely to act in an opportunistic manner, as monopolists were likely to do. Moreover, ownership by only one firm also helped to ensure the necessary coordination among the different segments of the industry (generation, transmission, distribution and retail supply). Furthermore, a general assumption was made about the strategic nature of the power industry for economic development, which justified both vertical integration and public ownership. In short, pre-reform structure of the electricity industry was primarily motivated by the existence of natural monopoly conditions, externalities, and so-called "public good" characteristics [3]. Therefore, historically, electricity industry as a whole was taken to be a natural monopoly, and legal monopoly model was adopted assuming that it is the most efficient one. In general, power industry was organized and operated under one of two basic structures: as state-owned enterprises under

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http://dx.doi.org/10.1016/j.rser.2013.11.014

government control or as privately owned regulated monopolies [4]. Many countries (e.g. most of the European countries) consolidated and nationalized their electricity industries into state-owned, legal monopolies while some other countries (e.g. Japan, US, Germany, Hong Kong) created private but regulated monopolies. So, over the last century, a large number of vertically integrated power companies, whether state or privately owned, have emerged under both models around the world, dominating the business.

Starting from 1980s, the rationality behind handling electricity industry as a vertically integrated monopoly has been questioned and various reform processes have been put into practice in many developed and developing countries of the world [1]. Although the reform steps have been more or less similar in developed and developing countries, the definition of success differs between developed and developing countries. In developed countries success of the reform depends mainly on how well the reformed electricity markets function; while in developing countries success usually means attracting capital from outside the country.

Bacon and Besant-Jones [5] argue that the process of a full reform program consists of the following four main stages: (a) formation and approval of a power policy by government that provides political commitment needed to sustain the reform process, followed by the enactment of legislation necessary for implementing this policy; (b) development of a transparent regulatory framework for the electricity market; (c) unbundling of the integrated structure of the power supply into generation, transmission, distribution and supply activities and establishing a market in which electricity is traded; and (d) divestiture of the state's ownership at least in most of the electricity generation and distribution segments of the market. So, key elements of a reform, in the suggested order, are: (i) regulation, (ii) restructuring, and (iii) where possible, privatization [6]. However, by no means all countries have adopted all of these changes; indeed, in most countries state ownership remains dominant, regulation remains largely untested, and competition is still restricted [7]. Moreover, in many cases, the initial market design had inherent flaws that only became apparent after the passage of some time. In nearly all these cases, initial market reform resulted in unintended consequences, which have been addressed in subsequent “reform of the reforms” [8]. In some instances, second and third waves of reforms have been initiated to address issues overlooked in the initial reform programs.

In almost all reforming countries (whether developed or developing), reforms in power markets have aimed at realizing two common objectives: (i) to enhance security of supply and (ii) to ensure that electricity industry develops in line with the requirements of sustainable development. Another common objective in developing countries (but not necessarily in developed ones) has been encouraging private investments in power industry. This paper questions the ability of the reforms to deliver these outcomes.

The paper proceeds as follows. Section 2 provides previous literature and presents research hypotheses. Section 3 summarizes the methodological framework. Section 4 describes data. Following section presents empirical analysis and discusses the results. The final section concludes.

2. Previous literature and research hypotheses

Table 1 summarizes econometric studies that provide cross-country evidence on the impact of electricity market reforms. Econometric studies on very limited number of countries or on non-electricity markets are not covered in Table 1.

This study tries to answer following research questions: (i) what is the impact of electricity market reforms on private investments in the electricity industries of developing countries?, (ii) does liberalization contribute to security of supply by increasing reserve margins?, (iii) what are the possible implications of power market reforms for sustainable development? and (iv) what are the other factors (apart from reform process) that influence private investments in developing countries, electricity reserve margins and impact of electricity generation on sustainable development; and how much are they influential relative to reform process?

As mentioned above, one of the key aims of the reform programs in developing countries has been reducing the burden of power sector investments on the public sector finance by getting private sector to invest in the electricity infrastructure. So, the first hypothesis to be tested in this study is:

Hypothesis 1. *As countries take more reform steps (that is, as the market moves further from monopoly and closer to competition), private investments in power industries of developing countries increase.*

Among the other basic targets of the electricity market reform initiatives, there has been increasing supply security, which is assumed to be materialized by extra electricity generation capacity added by private entrepreneurs. Therefore, the second hypothesis is formulated as below:

Hypothesis 2. *As countries introduce more and more reform steps, security of electricity supply increases.*

It is also argued that a free market, which is assumed to be an integral part of a free and democratic society, takes into account the requirements of sustainable development in every section of the economy and power industry is not an exception. Hence, the last hypothesis is:

Hypothesis 3. *Electricity market reforms contribute to efforts for sustainable development.*

To test these three hypotheses, at least three dependent variables and one independent variable are needed. Reserve margins and emissions from electricity generation (kg CO_2 per kWh) are employed as proxies for indicators of supply security and sustainable development, respectively. So, private investments in electricity sectors of developing countries, reserve margins and emissions from electricity generation constitute the dependent variables. As for independent variable, an index of electricity market openness is used to represent the progress in electricity market liberalization process. The detailed description of these variables is provided in the following sections of the paper. Based on the hypotheses above, a negative relationship between the electricity market openness index and emissions from electricity generation is expected. Besides, a positive relationship between reform progress on the one hand and private investments in developing countries and reserve margins on the other is anticipated.

In general, the large electricity consumers are one of the most influential players in any power market and industrial consumers are among the largest consumers. Therefore, it is reasonable to expect that industry sector, based on its self-interest, may try to have an impact on private investments, security of supply and emissions from electricity generation; and as its size gets bigger and bigger so does its influence. Also, the dependent variables are directly influenced by policy decisions to allow private investments. Therefore, the existence of such a political decision is important in the study. Besides, income and electricity consumption levels in a country may be important for the dependent variables. Private investors may prefer to invest in wealthier countries or in those with higher levels of electricity consumption to recover their investments easily. Securing supply security and sustainable development may be more difficult if the electricity consumption levels are higher and easier if the income levels are

Table 1
Previous literature.

Author	Data	Result
Steiner [3]	19 OECD countries for the period 1986–1996	Electricity market reforms generally resulted in a decline in the industrial price and an increase in the price differential between industrial customers and residential customers, indicating that industrial customers benefit more from the reform.
Bacon and Besant-Jones [5]		Country policy and institutions are positively correlated with reform. Country risk is negatively correlated with reform. Regional effects matter. For instance, Latin American and Caribbean countries are more likely to reform while countries in the Middle East and Africa are more likely to take fewer reform steps.
Ruffin [18]	75 developed and developing countries that reformed their electricity industries during the 1990s	The domestic adoption of market-oriented reforms is strongly influenced by international pressures of coercion and emulation. The coercive effect of multilateral lending is increasing over time, a finding that is consistent with anecdotal evidence that multilateral organizations have broadened the scope of the "conditionality" terms specifying market-oriented reforms imposed on borrowing countries. Countries imitate their trade-related peers, and sporadic support that countries with stronger political check and balances are more likely to adopt reforms.
Henisz et al. [19]	205 countries and territories between 1977 and 1999	The domestic adoption of market-oriented reforms is strongly influenced by international pressures of coercion and emulation. The coercive effect of multilateral lending is increasing over time, a finding that is consistent with anecdotal evidence that multilateral organizations have broadened the scope of the "conditionality" terms specifying market-oriented reforms imposed on borrowing countries. Countries imitate their trade-related peers, and sporadic support that countries with stronger political check and balances are more likely to adopt reforms.
Hattori and Tsutsui [20]	19 OECD countries for 1987–1999 period	Expanded retail access is likely to lower the industrial price. Unbundling of generation and introduction of a wholesale power market result in higher prices. A large share of private ownership lowers the industrial price.
Zhang et al. [7]	25 developing countries for the period 1985–2001	Establishing an independent regulatory authority and introducing competition before privatization is correlated with higher electricity generation, higher generation capacity and, in the case of the sequence of competition before privatization, improved capital utilization.
Fiorio et al. [21]	Electricity prices and survey data on consumer satisfaction in the EU-15	Privatization does not lead to lower prices, or to increased consumer satisfaction. The progress in the reform process is not systematically associated with lower prices and higher consumer satisfaction.
Zhang et al. [22]	36 developing and transitional countries over the period 1985–2003	On their own, privatization and regulation do not lead to obvious gains in economic performance, though there are some positive interaction effects. Introducing competition seems to be effective in stimulating performance improvements.
Mendoza and Pardo [23]	Four Latin-American countries over the period 1990–2006	Restructuring did not bring about environmental benefits related to a decrease in CO_2 emissions because this depends on the existence of committed policies, and dedicated institutional and regulatory frameworks. Power plants based on renewable energy sources decreased their share in installed capacity. The carbon index defined as CO_2 emission by unit of energy for electricity production stayed almost constant for all countries with the exception of Colombia, where the index reduced due to increase in hydroelectricity generation in the last years.
Cambini and Rondi [24]	A sample of EU energy utilities from 1997 to 2007	Investment rate is higher under incentive regulation than under rate of return regulation. Data on the regulatory tools (X factor and WACC) show that investment of incentive regulated firms appears highly sensitive to the X factor, consistent with efficiency- and profit-seeking motivations. Electric utilities investment is sensitive to the level and change in the weighted average cost of capital (WACC). The positive relationship between private control and investment is not robust to IV estimations, suggesting that in Europe regulation may have reduced the differences between private and public firms' incentives to invest.
Gugler et al. [25]	16 European countries over the period 1998–2007	Higher electricity end-user prices in a country subsequently lead to higher investments in the capital stock, i.e. in generation, distribution and transmission assets. There is a trade-off between vertical economies and competition. Ownership unbundling and forced access to the incumbent transmission grid increase competition but come at the cost of lost vertical economies. Regulation that affects only the market, like the establishment of a wholesale market or free choice of suppliers, increases investment activity via spurring competition. Regulation that adversely affects the incumbent directly, like ownership unbundling, decreases aggregate investment spending.

Table 1 (*continued*)

Author	Data	Result
Nagayama [26]	83 countries for 1985–2002 period	Independent regulator together with unbundling reduces electricity prices.
Nagayama [27]	73 countries for 1985–2003 period	Higher electricity prices are one of the main reasons for governments to adopt liberalization models, a conclusion also noted by Joskow [28] in the context of the US. The liberalization process in the electricity industry does not necessarily decrease electricity prices. Instead, there is a propensity for the prices to increase in every market model.
Nagayama [29]	86 countries between 1985 and 2006	Reform variables such as the entry of independent power producers (IPPs), unbundling of generation and transmission, establishment of regulatory agencies, and the introduction of a wholesale spot market are the driving forces of increasing generation capacity, as well as reducing transmission and distribution loss in the respective regions. Different electricity industry reform policies/measures have different impacts on geographically and economically diverse countries. A country's state of economic development has a different impact on policy effects of reforms. Coexistent with independent regulatory agencies, reform policy becomes more powerful in realizing sector performances.

higher. Moreover, European Union (EU) imposes many regulations on its member states and they directly influence private investments, security of supply and emissions from electricity generation. Furthermore, societies with democratic political institutions tend to encourage a liberal economic system in which private participation in power industry is encouraged; and the requirements of supply security and sustainable development are taken into account. Finally, population density and share of rural population are two factors that may influence the dependent variables too. Investors may have a tendency to invest in densely populated urban areas to maximize their revenues (and also profits) and it may be much easier to guarantee supply security and sustainable development in these areas because it is easier to organize and control electricity market operations in small areas in line with these considerations. Taking into account all these concerns, following control variables are included in the study: industry value added (as % of GDP), a dummy representing whether private investment is allowed, electricity consumption, GDP per capita, another dummy representing EU membership, polity score, population density, the share of rural population in total population.

3. Methodology

To construct a framework for analyzing the impact of the power market reforms on private investments in developing countries, security of supply and sustainable development, it is necessary to, first, evaluate possible impact of reforms on private investments in developing countries, security of supply and sustainable development; second, decide which indicators to use in the study and; finally, specify methods to measure them. Let me focus on these tasks one by one.

First of all, an accurate study of reform requires an analysis of its impact on the variables studied in this study. In many developing countries, one of the most important aims of the reforms has been attracting private capital into the power sector. That is, the reforms are expected to increase the amount of investments in electricity industry. Therefore, first of all, in this study whether reforms really cause private investments in developing countries to go up is checked. The reforms are also argued to respond to the requirements of security of supply and sustainable development. So, a positive relationship between reforms and security of electricity supply and a negative relationship between reforms and CO_2 emissions from electricity generation is also expected.

Second, to carry out the analysis suggested above, it is needed to decide which indicators to use in the study. Since the study focuses on the impact of the power market reforms on private investments in developing countries, security of supply and sustainable development, following four main variables are needed: (i) a variable for private investments in the electricity industries of developing countries, (ii) another variable measuring security of supply, (iii) a variable showing the relationship between reforms and sustainable development and (iv) a final variable representing the scale and intensity of the reform. In addition to these core variables, a set of control variables that are assumed to be endogenous to reform process and explain a portion of the variations in private investments in developing countries, security of supply and sustainable development is utilized. However, since the focus in this study is on the main variables, a specific type of relationship concerning control variables is neither expected nor suggested.

The measurement of the variables constitutes the final challenge in this study. Actually, most of the variables in this paper are measured in some form of monetary or physical unit; however, the extent and scope of electricity reforms have a qualitative dimension which is not measurable in physical units. To overcome this problem, as indicated by Jamasb et al. [9], an electricity market openness index constructed using data from international organizations such as OECD and EBRD is utilized in this study. The further details of variables used in this study are provided in the following section that overviews the data.

To detect the genuine effect of power market reforms on private investments in developing countries, security of supply and sustainable development, the effects of market reform should be separated from other country specific features. Therefore, the dependent variables are specified as a function of (i) electricity market openness index (a comparable cross-country reform indicator), (ii) a set of controls[1], (iii) country-specific effects (these are assumed to be exogenous and to exist independently of reform process, but may explain a portion of the variation in private

[1] Apart from reform process; private investments, security of supply and sustainable development in a specific country and year may be influenced by industry value added, whether private investment is allowed, electricity consumption, GDP per capita, whether the country is a member of EU, polity score, population density, rural population. In the models, all these variables are included in order to isolate the effect of the reform on private investments, security of supply and sustainable development.

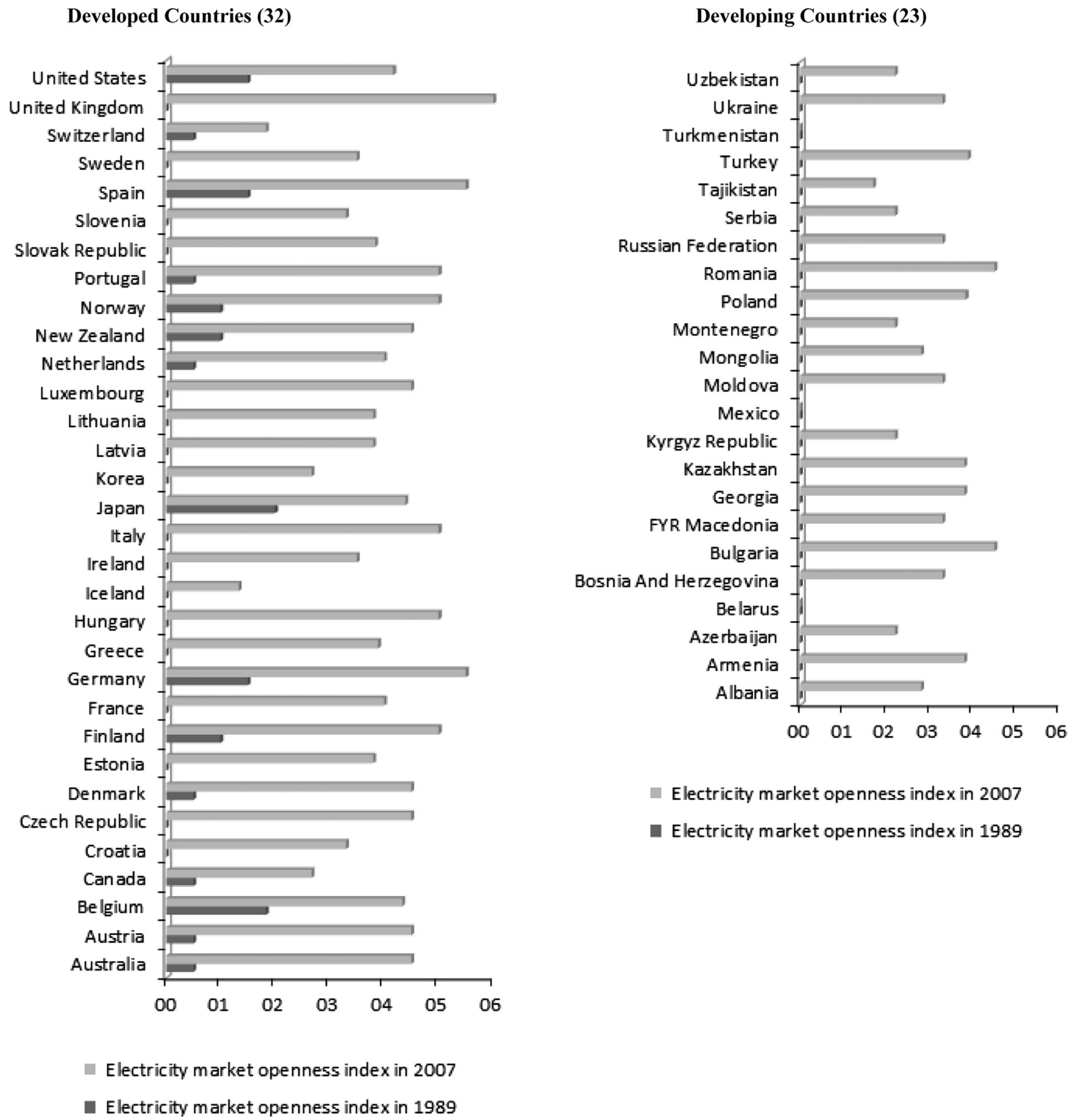


Fig. 1. The change in electricity market openness index from 1989 to 2007.

investments in developing countries, security of supply and sustainable development) and (iv) other unobserved variables that influence private investments in developing countries, security of supply and sustainable development.

In the empirical analysis, either a fixed effects (FE) or random effects (RE) regression is used in each model. In FE model, the country-specific effects are assumed to be the fixed parameters to be estimated. In RE model, the country-specific effects are treated as stochastic. The impact of the reform process on private investments in developing countries, security of supply and sustainable development may or may not be country specific as, in some cases, international or regional organizations (e.g. EU) impose rules on electricity industries that guarantee a minimum level of investment, supply security or emission reduction throughout a specific region. Therefore, the choice of regression specification (FE or RE) depends on relevant econometric tests, namely Hausman test and Breusch and Pagan Lagrangian Multiplier (BPLM) test.

4. Overview of data

The data set is based on a panel of 55 countries for a period beginning in 1975 and extending through 2010. List of countries in the data set is available in Fig. 1. Years 1975 and 2010 represent, respectively, the earliest and the last year for which data are available at the time the research is conducted. The countries in the sample are determined by data availability, especially by data on electricity market openness index. In the study, the total number of maximum observations for each variable is 1540. Because of the missing observations, the panel is unbalanced.

The variables used in the study are private investment in electricity sector, reserve margin, emissions from electricity generation, electricity market openness index, industry value added as % of GDP, dummy variable representing whether private investment is allowed, electricity consumption, GDP per capita, dummy for being an EU member, polity score, population density and rural

Table 2
Descriptive statistics of the variables in the models.

Variables (units)	Mean	Std. Dev.	Min	Max	# of Obser.	# of Countries
Dependent variables						
Private investment in electricity sector (current million US$)	104.66	704.33	0	12.412	378	17
Emissions from electricity generation (kg CO_2 per kWh)	0.44	0.32	0.0005	2.59	1374	54
Reserve margin	0.49	0.26	−0.0024	1.55	693	29
Explanatory variable						
Electricity market openness index (0–6)	1.54	1.61	0	6	1540	55
Control variables						
Industry value added (% of GDP)	32.39	7.43	10.29	69.92	1415	55
Dummy, =1 if private investment is allowed	0.35	0.48	0	1	1540	55
Electricity consumption (MWh per capita)	5.90	4.99	0.34	36.85	1450	54
GDP per capita (PPP, current thousand int. $)	14.34	10.83	0.73	84.41	1307	55
Dummy, =1 if EU member	0.30	0.46	0	1	1540	55
Polity score (−10,+10)	6.31	6.13	−10	10	1357	53
Population density (people per sq. km of land area)	101.26	104.35	1.40	499.96	1428	55
Rural population (% of total population)	33.95	14.47	2.66	73.60	1514	55

population. All countries in the dataset are divided into two groups based on income level (developed and developing countries). The country classification in this study is in line with one made by World Bank [10]. A dummy variable for each group of country is included into the dataset.

The data on private investment in electricity sector are obtained from World Bank [11] and available only for developing countries. Reserve margin is used to measure security of supply. It is calculated by dividing the difference between total installed electricity capacity and peak load by peak load. Reserve margin represents the amount by which the utility's total electric power capacity exceeds maximum electric demand. The higher the reserve margin, the more secure is a country's electricity supply. Data on total installed electricity capacity and peak load come from IEA [12]. Data on CO_2 emissions from electricity generation are taken from IEA [13].

The data on electricity market openness index are constructed using data from Conway and Nicolett [14] and EBRD[2] [15]. Conway and Nicolett [14] provide an electricity market index for 30 OECD countries covering the period from 1975 to 2007. The index ranges from 0 to 6 where 0 represents the fully open market in which entry barriers, public ownership and vertical integration are minimized and a score of 6 is given to a closed market. EBRD [15] provides a similar indicator for additional 25 developing countries where EBRD operates for the period 1989–2010. The data from EBRD [15] are available on a 1–4 scale. To establish uniformity between two data sets, the data from EBRD [15] are converted into 6–0 scale. Whole data is transformed once more to get an electricity market openness index where 6 represents the fully open market and 0 symbolizes a closed market. Fig. 1 provides the change in electricity market openness index from 1989 to 2007 for the countries in the dataset.

The data regarding industry value added as % of GDP and rural population as % of total population are taken from World Bank [16]. Dummy variables representing being an EU member and whether private investment is allowed are constructed by the author. World Bank [16] provides data on population density (people per sq. km of land area), electricity consumption (MWh per capita), and GDP per capita (PPP, current thousand int. $). Polity score data come from Center for Systemic Peace [17] and measures the degree of political democracy in each country and year. This indicator ranges between −10 and +10. It is created by Center for Systemic Peace by taking into account the competitiveness of political participation, the openness and competitiveness of executive recruitment, and constraints on the chief executive. Table 2 shows descriptive statistics of the variables in the analysis.

5. Empirical analysis and discussion of the results

Throughout the analysis, three groups of models are estimated to explain the impact of power market reforms on (i) private investments in power industries of developing countries, (ii) security of supply and (iii) sustainable development. Each group includes an overall model including all countries, a sub-group for developed countries and another sub-group for developing countries. Since the data on private investment in power industry are available only for developing countries, in the first group, a model is estimated for developing countries only. So, in total, 7 models[3] are estimated. Table 3 provides a summary of estimation results.

In the first model, the empirical findings support the idea that reform process discourages investment in developing countries. In Model 1, the sign of the coefficient of electricity market openness index is negative and it is significant even at 1% level, meaning that as countries move from a monopoly market structure to a competitive one private participation in power industry decreases. Based on the results, on average, every one point increase in 6-point scale openness index results in a decrease of $205 million investment by private sector in electricity industries of developing countries. This result may verify the idea that private entrepreneurs prefer to invest in developing countries where governments guarantee a certain amount of return on their investment rather than in those where they have to operate in a competitive market to recover their investment and to make a profit.

The results show a negative correlation between private investments and the size of industry sector, meaning that countries with a larger industrial sector are less likely to attract private (and usually foreign) investment. This may be an indication that industrial consumers prefer guaranteed subsidized prices in a closed market to the possibility of future reduced prices in a liberal market.

The results imply that in developing countries where private investment in power industry is allowed, investors take this opportunity and invest $511 million on average. Besides, a positive relationship is observed between private investments and income

[2] European Bank for Reconstruction and Development.

[3] Throughout the paper, model estimations are carried out and cross-checked by Stata 12 and Eviews 7.

Table 3
Summary of estimation results.

Dependent variables → explanatory variables ↓		Private investment in electricity sector (current million US$)	Reserve margin	Emissions (kg CO_2 per kWh)
Electricity market openness (0–6)	*All countries*	–	0.021*** (3.78)	−0.009*** (−4.2)
	Developed countries	–	0.01* (1.77)	−0.01*** (−4.35)
	Developing countries	−205.289*** (−3.68)	0.046*** (2.75)	*NS*
Industry value added (% of GDP)	*All countries*	–	*NS*	*NS*
	Developed countries	–	*NS*	0.004*** (3.65)
	Developing countries	−24.077*** (−2.88)	*NS*	−0.002** (−2.23)
Dummy, =1 if private investment is allowed	*All countries*	–	−0.07*** (−4.5)	*NS*
	Developed countries	–	−0.072*** (−4.49)	0.028*** (3.89)
	Developing countries	511.059*** (3.01)	−0.169*** (−3.99)	*NS*
Electricity consumption (MWh per capita)	*All countries*	–	−0.04*** (−5.56)	0.017*** (5.29)
	Developed countries	–	−0.032*** (−4.99)	0.013*** (4.66)
	Developing countries	*NS*	−0.12* (−1.75)	0.049*** (3.4)
GDP per capita (PPP, current 1000 int. $)	*All countries*	–	*NS*	−0.004*** (−6.57)
	Developed countries	–	0.005*** (3.56)	−0.004*** (−6.13)
	Developing countries	174.702*** (*5.6*)	*NS*	*NS*
Dummy, =1 if EU member	*All countries*	–	*NS*	0.022** (2.48)
	Developed countries	–	*NS*	0.025*** (2.58)
	Developing countries	−768.57** (−2.4)	*NS*	*NS*
Polity score (−10, +10)	*All countries*	–	0.019*** (7.54)	−0.003*** (−3.6)
	Developed countries	–	*NS*	−0.021** (−2.28)
	Developing countries	*NS*	0.014*** (4.22)	−0.005*** (−4.11)
Population density (people per sq. km)	*All countries*	–	*NS*	−0.003*** (−7.12)
	Developed countries	–	*NS*	−0.004*** (−6.45)
	Developing countries	22.504* (1.77)	−0.012* (−1.98)	*NS*
Rural population (% of total population)	*All countries*	–	0.006* (1.7)	−0.006*** (−4.44)
	Developed countries	–	0.012*** (3.3)	−0.006*** (−2.71)
	Developing countries	112.313*** (3.74)	−0.02* (−1.98)	*NS*
Constant	*All countries*	–	*NS*	0.904*** (10.36)
	Developed countries	–	*NS*	1.073*** (6.73)
	Developing countries	−6114.218*** (−3.22)	2.275** (2.43)	0.386*** (3.22)

Standard errors are shown in parentheses () after coefficients.
"–": Not a variable in the models.
"NS": The coefficient is not significant even at 10% level.

*** Coefficient that is significant at 1% level.
** Coefficient that is significant at 5% level.
* Coefficient that is significant at 10% level.

level. So, investors seem to prefer to invest in wealthier developing countries.

Private investments in developing countries are also positively correlated with population density and rural population, meaning that densely populated countries where people prefer to live in rural areas attract more private investment. Furthermore, the findings indicate that being an EU member discourages private investments. The results show that if a developing country is an EU member then this country receives $769 million less investment compared to non-member countries.

As for the impact of reforms on security of electricity supply, there is a positive relationship between reforms and reserve margins. In the overall model (Model 2.1), it is evident that a full liberalization process increases reserve margins by 13%. For instance, on average, if a country with a monopoly market structure and a reserve margin of 2% introduces competitive market model in its power industry, the reserve margin in this country is expected to rise to 15%. This impact is especially huge in developing countries.

A negative relationship between reserve margins and electricity consumption is detected. As electricity consumption increases, reserve margins decline. This tendency holds true in both developed and developing countries. In addition, reserve margins are positively correlated with income level in developed countries and polity score in developing countries. They have also a negative correlation with population density in developing countries. As for rural population, any increase in the share of rural population seems to raise reserve margins in developed countries but reduce them in developing ones.

The study reveals that there is a negative relationship between reform process and CO_2 emissions from electricity generation (Model 3.1). This is especially true for developed countries (Model 3.2). For instance, according to the results, a full liberalization process decreases emissions from electricity generation by 60 g CO_2 per kWh in developed countries. However, for developing countries, the coefficient of market openness index is not significant at all (Model 3.3).

An increase in the size of the industry sector seems to increase emissions from electricity generation in developed countries but decrease them in developing ones. Also, emissions from electricity generation are positively correlated with electricity consumption but negatively correlated with polity score. Therefore, more democratic countries with lower levels of electricity consumption generate electricity with lower level of emissions. Besides, income level, population density and the share of rural population have a negative correlation with emissions from electricity generation. This tendency is especially valid for developed countries. Surprisingly, being an EU member increases emissions in developed countries. In developing countries, there is not a specific link between these variables and emissions from electricity generation. Finally, country specific features

tend to have a high power in explaining private investments and security of supply in developing countries, and sustainable development in both developed and developing countries.

To sum up, based on the results, Hypothesis 1 is rejected but Hypotheses 2 and 3 are not rejected. Overall, the results reveal that the progress toward the electricity market reform is associated with less private investments in developing countries, higher levels of self-sufficiency in electricity generation and lower CO_2 emissions from electricity generation. However, although the conclusions verify the idea that electricity market reform process (with privatization, liberalization and vertical disintegration) discourages investment, strengthens security of supply and contributes to sustainable development; it does not necessarily involve a judgment on the overall success of the reform process. The variables focused on in this paper are just some of the expectations from the reform and the process should be judged based on its overall impact (not only its impact on investments, security of supply and sustainable development).

6. Conclusion

In the study, empirical econometric models are constructed to observe the impact of electricity market reforms on private investments in developing countries, security of supply and sustainable development. Panel data from 55 countries covering the period from 1975 to 2010 were employed. It is found that liberalization process gives rise to an increase in electricity self-sufficiency while it decreases private electricity infrastructure investments in developing countries and CO_2 emissions from electricity generation. The results suggest that liberalization process does not bring about the most important reform target of developing countries, namely attracting foreign investment, but it does fulfill some objectives targeted mainly by developed countries, that are self-sufficiency in electricity supply and a more sustainable development oriented electricity industry.

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